CLAIMS

What Is Claimed Is:

1. A polymeric composition having antimicrobial properties, the polymeric composition comprising:

a crosslinked chemical combination of (i) a polymer having side chains along a backbone forming the polymer, at least two of the side chains containing an amino group, (ii) an antimicrobial agent selected from quaternary ammonium compounds, gentian violet compounds, substituted or unsubstituted phenols, biguanide compounds, iodine compounds, and mixtures thereof, and (iii) a crosslinking agent containing at least two functional groups capable of reacting with the amino groups.

2. The polymeric composition of claim 1 wherein:

the polymer is a polyamide, and

the polymer is synthesized by (i) reacting a monomer selected from unsaturated carboxylic acids, esters of unsaturated carboxylic acids, anhydrides of unsaturated carboxylic acids, and mixtures thereof, and a first amine to form an intermediate reaction product, wherein the first amine is selected from RR_1NH, RNH_2, $RR_1NH_2^+$, RNH_3^+ and mixtures thereof, wherein R and R_1 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, and (ii) reacting the intermediate reaction product and a second amine to form the polyamide, wherein the second amine is selected from R_2R_3NH, R_2NH_2, $R_2R_3NH_2^+$, $R_2NH_3^+$ and mixtures thereof, wherein R_2 and R_3 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, wherein multiples of the R, R_1, R_2, and R_3 are in vertically aligned spaced relationship along a backbone formed by the polyamide.

3. The composition of claim 2 wherein R and R_1 are alkyl and the second amine is a polyalkylene polyamine.

4. The composition of claim 3 wherein the first amine is tetradecylamine and the polyalkylene polyamine is pentaethylenehexamine.

5. The composition of claim 2 wherein the monomer is selected from unsaturated dicarboxylic acids, esters of unsaturated dicarboxylic acids, anhydrides of unsaturated dicarboxylic acids. and mixtures thereof.

6. The composition of claim 5 wherein the monomer is selected from maleic anhydride, maleic acid esters, and mixtures thereof.

7. The polymeric composition of claim 2 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, dimethylchlorophenol, triclosan, thymol, chlorhexidine, iodine, and mixtures thereof.

8. The composition of claim 1 wherein:

the polymer is a polyamide. and

the polymer is synthesized by (i) reacting an α,β-unsaturated lactone and a first amine to form an intermediate reaction product, wherein the first amine is selected from RR_1NH, RNH_2, $RR_1NH_2^+$, RNH_3^+ and mixtures thereof, wherein R and R_1 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, and (ii) reacting the intermediate reaction product and a second amine to form the polyamide, wherein the second amine is selected from R_2R_3NH, R_2NH_2, $R_2R_3NH_2^+$, $R_2NH_3^+$ and mixtures thereof, wherein R_2 and R_3 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, wherein multiples of the R, R_1, R_2, and R_3 are in vertically aligned spaced relationship along a backbone formed by the polyamide.

9. The composition of claim 8 wherein R and R_1 are alkyl and the second amine is a polyalkylene polyamine.

10. The composition of claim 9 wherein the first amine is tetradecylamine and the polyalkylene polyamine is pentaethylenehexamine.

11. The composition of claim 8 wherein the lactone is 2(5H)-furanone.

12. The composition of claim 8 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, dimethylchlorophenol, triclosan, thymol, chlorhexidine, iodine, and mixtures thereof.

13. The composition of claim 1 wherein the crosslinking agent is selected from the group consisting of phosphines having the general formula $(A)_3P$, wherein A is hydroxyalkyl, and mixtures thereof.

14. The composition of claim 13 wherein the crosslinking agent is tris(hydroxymethyl)phosphine.

15. The composition of claim 1 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, dimethylchlorophenol, triclosan, thymol, chlorhexidine, iodine, and mixtures thereof.

16. The composition of claim 1 wherein the antimicrobial agent includes chlorhexidine and dimethylchlorophenol.

17. The composition of claim 1 wherein the antimicrobial agent is dimethylchlorophenol.

18. The composition of claim 16 wherein the antimicrobial agent is triclosan.

19. The composition of claim 1 wherein the antimicrobial agent is thymol.

20. The composition of claim 1 wherein the antimicrobial agent is cetyl pyridinium chloride.

21. The composition of claim 1 wherein the antimicrobial agent is gentian violet or dimethyl gentian violet.

22. The composition of claim 1 wherein the antimicrobial agent is chlorhexidine.

23. The composition of claim 1 wherein the antimicrobial agent is iodine or an iodine complex.

24. A process for rendering the surface of a substrate antimicrobial, the process comprising:

(a) providing a polymer having side chains along a backbone forming the polymer, at least two of the side chains containing an amino group;

(b) mixing the polymer with a first crosslinking agent, to produce a polymer solution, the first crosslinking agent containing at least two crosslinking functional groups capable of reacting with the amino groups;

(c) coating at least a portion of the substrate with the polymer solution to produce a crosslinked polymer coating on the substrate;

(d) mixing a second crosslinking agent and an antimicrobial agent selected from gentian violet compounds, substituted or unsubstituted phenols, biguanide compounds, and mixtures thereof, to produce a coating solution, the second crosslinking agent containing at least two crosslinking functional groups capable of reacting with the amino groups; and

(e) applying the coating solution to the crosslinked polymer coating on the substrate.

25. The process of claim 24 further comprising:

(f) applying an iodine compound to the crosslinked polymer coating on the substrate after applying the coating solution to the crosslinked polymer coating on the substrate.

26. The process of claim 24 wherein:

the first crosslinking agent is selected from the group consisting of polyaldehydes, phosphines having the general formula $(A)_3P$, wherein A is hydroxyalkyl, and mixtures thereof, and

the second crosslinking agent is selected from the group consisting of phosphines having the general formula $(A)_3P$, wherein A is hydroxyalkyl, and mixtures thereof.

27. The process of claim 24 wherein the substrate comprises a polymeric material selected from polyolefins, polyacrylics, polyvinyl chloride, polyamides, polyurethanes, polyurethaneureas, silicone urethane copolymers, polyvinylpyrrolidone, polyvinyl alcohols, cellulosic materials, polystyrene, polyesters, fluorinated polymers, silicone polymers, natural rubber, polycarbonates, and mixtures thereof.

28. The process of claim 24 wherein the antimicrobial agent is selected from gentian violet, dimethyl gentian violet, dimethylchlorophenol, chlorhexidine, and mixtures thereof.

29. The process of claim 24 wherein:

the polymer is a polyamide. and

step (a) comprises: (i) reacting a monomer selected from unsaturated carboxylic acids, esters of unsaturated carboxylic acids, anhydrides of unsaturated carboxylic acids, and mixtures thereof, and a first amine to form an

intermediate reaction product, wherein the first amine is selected from RR_1NH, RNH_2, $RR_1NH_2^+$, RNH_3^+ and mixtures thereof, wherein R and R_1 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof; and (ii) reacting the intermediate reaction product and a second amine to form the polyamide, wherein the second amine is selected from R_2R_3NH, R_2NH_2, $R_2R_3NH_2^+$, $R_2NH_3^+$ and mixtures thereof, wherein R_2 and R_3 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, wherein multiples of the R, R_1, R_2, and R_3 are in vertically aligned spaced relationship along a backbone formed by the polyamide.

30. The process of claim 29 wherein R and R_1 are alkyl and the second amine is a polyalkylene polyamine.

31. The process of claim 29 wherein the monomer is selected from maleic anhydride, maleic acid esters, and mixtures thereof.

32. The process of claim 29 wherein the antimicrobial agent is selected from gentian violet, dimethyl gentian violet, dimethylchlorophenol, chlorhexidine, and mixtures thereof.

33. The process of claim 24 wherein:

the polymer is a polyamide, and

step (a) comprises: (i) reacting an α,β-unsaturated lactone and a first amine to form an intermediate reaction product, wherein the first amine is selected from RR_1NH, RNH_2, $RR_1NH_2^+$, RNH_3^+ and mixtures thereof, wherein R and R_1 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof; and (ii) reacting the intermediate reaction product and a second amine to form the polyamide, wherein the second amine is

selected from R_2R_3NH, R_2NH_2, $R_2R_3NH_2^+$, $R_2NH_3^+$ and mixtures thereof, wherein R_2 and R_3 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, wherein multiples of the R, R_1, R_2, and R_3 are in vertically aligned spaced relationship along a backbone formed by the polyamide.

34. The process of claim 33 wherein R and R_1 are alkyl and the second amine is a polyalkylene polyamine.

35. The process of claim 33 wherein the antimicrobial agent is selected from gentian violet, dimethyl gentian violet, dimethylchlorophenol, chlorhexidine, and mixtures thereof.

36. A process for rendering the surface of a substrate antimicrobial, the process comprising:

(a) providing a polymer having side chains along a backbone forming the polymer, at least two of the side chains containing an amino group;

(b) mixing the polymer with a crosslinking agent to produce a polymer solution, the crosslinking agent containing at least two crosslinking functional groups capable of reacting with the amino groups;

(c) coating at least a portion of the substrate with the polymer solution to produce a crosslinked polymer coating on the substrate;

(d) treating at least a portion of the crosslinked polymer coating with a charge derivatization agent to create a negative charge on the portion of the crosslinked polymer coating; and

(e) applying a cationic antimicrobial agent selected from quaternary ammonium compounds, gentian violet compounds, biguanide compounds, iodine compounds, and mixtures thereof, to the portion of the crosslinked polymer coating.

37. The process of claim 36 wherein:

the crosslinking agent is selected from the group consisting of polyaldehydes, phosphines having the general formula $(A)_3P$, wherein A is hydroxyalkyl, and mixtures thereof.

38. The process of claim 36 wherein:

the crosslinking agent is selected from the group consisting of phosphines having the general formula $(A)_3P$, wherein A is hydroxyalkyl, and mixtures thereof.

39. The process of claim 36 wherein the substrate comprises a polymeric material selected from polyolefins, polyacrylics, polyvinyl chloride, polyamides, polyurethanes, polyurethaneureas, silicone urethane copolymers, polyvinylpyrrolidone, polyvinyl alcohols, cellulosic materials, polystyrene, polyesters, fluorinated polymers, silicone polymers, natural rubber, polycarbonates, and mixtures thereof.

40. The process of claim 36 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, chlorhexidine, iodine, and mixtures thereof.

41. The process of claim 36 wherein:

the polymer is a polyamide, and

step (a) comprises: (i) reacting a monomer selected from unsaturated carboxylic acids, esters of unsaturated carboxylic acids, anhydrides of unsaturated carboxylic acids, and mixtures thereof, and a first amine to form an intermediate reaction product, wherein the first amine is selected from RR_1NH, RNH_2, $RR_1NH_2^+$, RNH_3^+ and mixtures thereof, wherein R and R_1 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof; and (ii) reacting the intermediate reaction product and a second amine to form the polyamide, wherein the second amine is selected from R_2R_3NH, R_2NH_2, $R_2R_3NH_2^+$, $R_2NH_3^+$ and mixtures thereof, wherein R_2 and R_3 can be the same or different and each contain between about 1 and 50 carbon atoms

and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, wherein multiples of the R, R_1, R_2, and R_3 are in vertically aligned spaced relationship along a backbone formed by the polyamide.

42. The process of claim 41 wherein R and R_1 are alkyl and the second amine is a polyalkylene polyamine.

43. The process of claim 41 wherein the monomer is selected from maleic anhydride, maleic acid esters, and mixtures thereof.

44. The process of claim 41 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, chlorhexidine, iodine, and mixtures thereof.

45. The process of claim 36 wherein:

the polymer is a polyamide; and

step (a) comprises: (i) reacting an α,β-unsaturated lactone and a first amine to form an intermediate reaction product, wherein the first amine is selected from RR_1NH, RNH_2, $RR_1NH_2^+$, RNH_3^+ and mixtures thereof, wherein R and R_1 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof; and (ii) reacting the intermediate reaction product and a second amine to form the polyamide, wherein the second amine is selected from R_2R_3NH, R_2NH_2, $R_2R_3NH_2^+$, $R_2NH_3^+$ and mixtures thereof, wherein R_2 and R_3 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, wherein multiples of the R, R_1, R_2, and R_3 are in vertically aligned spaced relationship along a backbone formed by the polyamide.

46. The process of claim 45 wherein R and R_1 are alkyl and the second amine is a polyalkylene polyamine.

47. The process of claim 45 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, chlorhexidine, iodine, and mixtures thereof.

48. A process for rendering the surface of a substrate antimicrobial, the process comprising:

(a) providing a polymer having side chains along a backbone forming the polymer, at least two of the side chains containing an amino group;

(b) mixing the polymer with a crosslinking agent and an antimicrobial agent selected from quaternary ammonium compounds, gentian violet compounds, substituted or unsubstituted phenols, biguanide compounds, iodine compounds, and mixtures thereof, to produce a polymer solution, the crosslinking agent containing at least two crosslinking functional groups capable of reacting with the amino groups; and

(c) coating at least a portion of the substrate with the polymer solution to produce a crosslinked polymer coating on the substrate.

49. The process of claim 48 wherein:

the crosslinking agent is selected from the group consisting of polyaldehydes, phosphines having the general formula $(A)_3P$, wherein A is hydroxyalkyl, and mixtures thereof.

50. The process of claim 48 wherein:

the crosslinking agent is selected from the group consisting of phosphines having the general formula $(A)_3P$, wherein A is hydroxyalkyl, and mixtures thereof.

51. The process of claim 48 wherein the substrate comprises a polymeric material selected from polyolefins, polyacrylics, polyvinyl chloride, polyamides, polyurethanes, polyurethaneureas, silicone urethane copolymers,

polyvinylpyrrolidone, polyvinyl alcohols, cellulosic materials, polystyrene, polyesters, fluorinated polymers, silicone polymers, natural rubber, polycarbonates, and mixtures thereof.

52. The process of claim 48 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, dimethylchlorophenol, triclosan, thymol, chlorhexidine, iodine, and mixtures thereof.

53. The process of claim 48 wherein:

the polymer is a polyamide, and

step (a) comprises: (i) reacting a monomer selected from unsaturated carboxylic acids, esters of unsaturated carboxylic acids, anhydrides of unsaturated carboxylic acids, and mixtures thereof, and a first amine to form an intermediate reaction product, wherein the first amine is selected from RR_1NH, RNH_2, $RR_1NH_2^+$, RNH_3^+ and mixtures thereof, wherein R and R_1 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof; and (ii) reacting the intermediate reaction product and a second amine to form the polyamide, wherein the second amine is selected from R_2R_3NH, R_2NH_2, $R_2R_3NH_2^+$, $R_2NH_3^+$ and mixtures thereof, wherein R_2 and R_3 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, wherein multiples of the R, R_1, R_2, and R_3 are in vertically aligned spaced relationship along a backbone formed by the polyamide.

54. The process of claim 53 wherein R and R_1 are alkyl and the second amine is a polyalkylene polyamine.

55. The process of claim 53 wherein the monomer is selected from maleic anhydride, maleic acid esters. and mixtures thereof.

56. The process of claim 53 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, dimethylchlorophenol, triclosan, thymol, chlorhexidine, iodine, and mixtures thereof.

57. The process of claim 48 wherein:

the polymer is a polyamide, and

step (a) comprises: (i) reacting an α,β-unsaturated lactone and a first amine to form an intermediate reaction product, wherein the first amine is selected from RR_1NH, RNH_2, $RR_1NH_2^+$, RNH_3^+ and mixtures thereof, wherein R and R_1 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof; and (ii) reacting the intermediate reaction product and a second amine to form the polyamide, wherein the second amine is selected from R_2R_3NH, R_2NH_2, $R_2R_3NH_2^+$, $R_2NH_3^+$ and mixtures thereof, wherein R_2 and R_3 can be the same or different and each contain between about 1 and 50 carbon atoms and are optionally substituted with heteroatoms oxygen, nitrogen, sulfur, and phosphorus and combinations thereof, wherein multiples of the R, R_1, R_2, and R_3 are in vertically aligned spaced relationship along a backbone formed by the polyamide.

58. The process of claim 57 wherein R and R_1 are alkyl and the second amine is a polyalkylene polyamine.

59. The process of claim 57 wherein the antimicrobial agent is selected from cetyl pyridinium chloride, gentian violet, dimethyl gentian violet, dimethylchlorophenol, triclosan, thymol, chlorhexidine, iodine, and mixtures thereof.